

BREEDING SEASON AND PRODUCTIVITY OF MONK PARAKEETS IN CORDOBA, ARGENTINA

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ABSTRACT.—We studied the breeding productivity of populations of the Monk Parakeet (*Myiopsitta monachus*), at Arroyito and Jesús María, Córdoba province, Argentina. In Arroyito, nests were in introduced eucalyptus trees, whereas in Jesús María nesting was entirely in native tree species. Egg laying started on around 1 November, although onset of breeding varied significantly among years within a three-week period. Start of egg laying within the populations was extended for nine weeks on average. The percentage of occupied nest chambers found with eggs was significantly higher at Arroyito (91%) than at J. María (overall mean 53%). At Arroyito, mean first clutch size was significantly higher (6 eggs) than at J. María (5.4 eggs). Replacement and second clutches were significantly smaller than the first clutches in both areas. Hatching success did not differ between areas (58%, both combined) but differed significantly among years at J. María. A higher percentage of nestlings reached fledging age at Arroyito (53%) than at J. María (42%). Mean number of young fledged per breeding pair was 2.2 at Arroyito and 1.4 (overall) at J. María (range: 0.5–2.3). The apparent preference exhibited by Monk Parakeets for nesting in eucalyptus trees against low native vegetation could be a result of the higher productivity of breeding pairs in the former habitat. The Monk Parakeet has a lower fledging and breeding success than other parrots. Due to its large clutch size, however, it has one of the largest productivities among psittacids. Received 1 Aug. 1991, accepted 1 Feb. 1992.

The Monk Parakeet's (*Myiopsitta monachus*) nesting habits are unique among psittacids. Whereas most parrots are hole or cavity nesters, this species builds large enclosed stick nests, which often are integrated in a compound nest that may include several isolated chambers (Forshaw 1978). These large communal nests closely resemble those of the Sociable Weaver (*Philetairus socius*) of Africa (Collias and Collias 1978). Unlike the majority of birds, Monk Parakeets occupy their nests throughout the year. During the non-breeding season, each nest chamber is inhabited by a variable number of individuals (juvenile and adults), whereas only a single breeding pair or two to three non-breeding birds occupy the nest in the breeding season (Martella 1985, Martín 1989). There is evidence suggesting that the social organization of this parakeet is complex (Martella 1985, Martín 1989) and has some characteristics of a communal breeder such as delayed breeding, reduced dispersal, and incipient helping (Bucher et al., in press). The Monk Parakeet is considered a pest throughout its range. Complaints include damage to crops (Bucher 1984) and to

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artificial structures such as power lines (Bucher and Martin 1987). Control campaigns usually are based on direct killing without a proper understanding of the population dynamics of the Monk Parakeet. This may either make those control methods ineffective or eventually threaten the survival of this species. The Monk Parakeet is also exploited for the bird trade (Nilsson 1990).

In this paper, we present the results of a long-term study of the breeding biology of the Monk Parakeet. Besides providing general information on the subject, we discuss differences in reproductive output that may be associated with the apparent preference for nesting in eucalyptus compared to native trees.

STUDY AREAS AND METHODS

This study was conducted in two areas of Córdoba province, Argentina. One area was located at "San Antonio" ranch (31°25'S, 62°59'W), near the town of Arroyito, and the other was at "Los Leones" ranch (31°05'S, 64°11'W), close to the town of Jesus María. In both areas, the native vegetation has been cleared for agriculture and cattle-raising, leaving some interspersed remnants of the original xerophytic woodland. Mean annual rainfall at Arroyito is 700 mm and at J. María 870 mm (75% occurring between November and March). The daily temperature in both sites ranges from an average minimum of 4°C in July to a mean maximum of 30°C in January.

Our Monk Parakeet populations were studied from the pre-laying period (October) to post-fledging time (early March) at Arroyito in 1982 and at J. María from 1983 to 1988. In Arroyito, the studied nests were all grouped in rows of *Eucalyptus viminalis* trees planted at both sides of the 1000-m long ranch's entrance. In J. María, the nests were in native trees (*Celtis tala*, *Geoffroea decorticans*, *Aspidosperma quebrachoblanco* and *Prosopis* spp.) in a 610-ha study area where some nests were isolated and others were grouped. Because native trees do not grow as high as eucalyptus, nests at J. María were constructed below 10 m of height (roughly), whereas at Arroyito almost all nests were in higher locations.

In Arroyito, all accessible nests situated below 16 m in the first 400 m of the eucalyptus plantation were checked weekly with a cherry-picker. All eggs found were marked with a soft pencil, and the number of eggs and chicks was recorded on each visit. At J. María, all nests below a height of 6 m in the study area (about 70% of total) were inspected using a ladder at 10-day intervals on average (range 7–12). In this area, the eggs were marked individually with indelible ink, and after hatching, the chicks of the same nest initially were identified by clipping a different claw. From 1985 to 1987, nestlings were weighed (using Pesola spring scales) to the nearest 0.1 g for masses <10 g and to the nearest 1 g for chicks >10 g. In both areas nestlings were banded with numbered aluminum bands when they reached about 20 days old.

The date of clutch initiation was estimated for each nest chamber by back-dating, based on a 2.1-day interval between successive eggs and a 24-day incubation period (Navarro 1989). The age of nestlings, calculated by a growth curve equation (Navarro and Bucher 1990), was also used for back-dating when necessary. Although these methods provided accurate dating in most cases, there were some clutches in which no laying date could be estimated (e.g., found as a completed clutch with several eggs which did not hatch).

The fate of each egg was recorded as lost before hatching, failed to hatch, or hatched. Eggs that might have hatched but whose chicks disappeared before the following visit were

assumed not to have hatched. A juvenile was considered to have fledged when absent from the nest at ≥ 35 days after hatching. Disappearances at earlier ages were considered to be deaths. Causes of loss of eggs and chicks were assigned to (1) predation: eggs and chicks in nests in which there was evidence of predator attack (remains of mutilated carcasses) or there was a simultaneous loss of the whole nest's content without trace; (2) partial disappearance: vanishing of part of the clutch or brood, eggs falling from the nest, and a few cases when a total loss occurred after a partial loss; (3) failure to hatch: infertile eggs, death of the embryo, or desertion; (4) deaths in the nest: malnutrition, malformation, or sickness; (5) nest fall; and (6) manipulation.

First clutches refer here to the female's laying her first egg in the season; replacement clutches were those started following failure of the first clutch, and second clutches are those laid after a successful first brood.

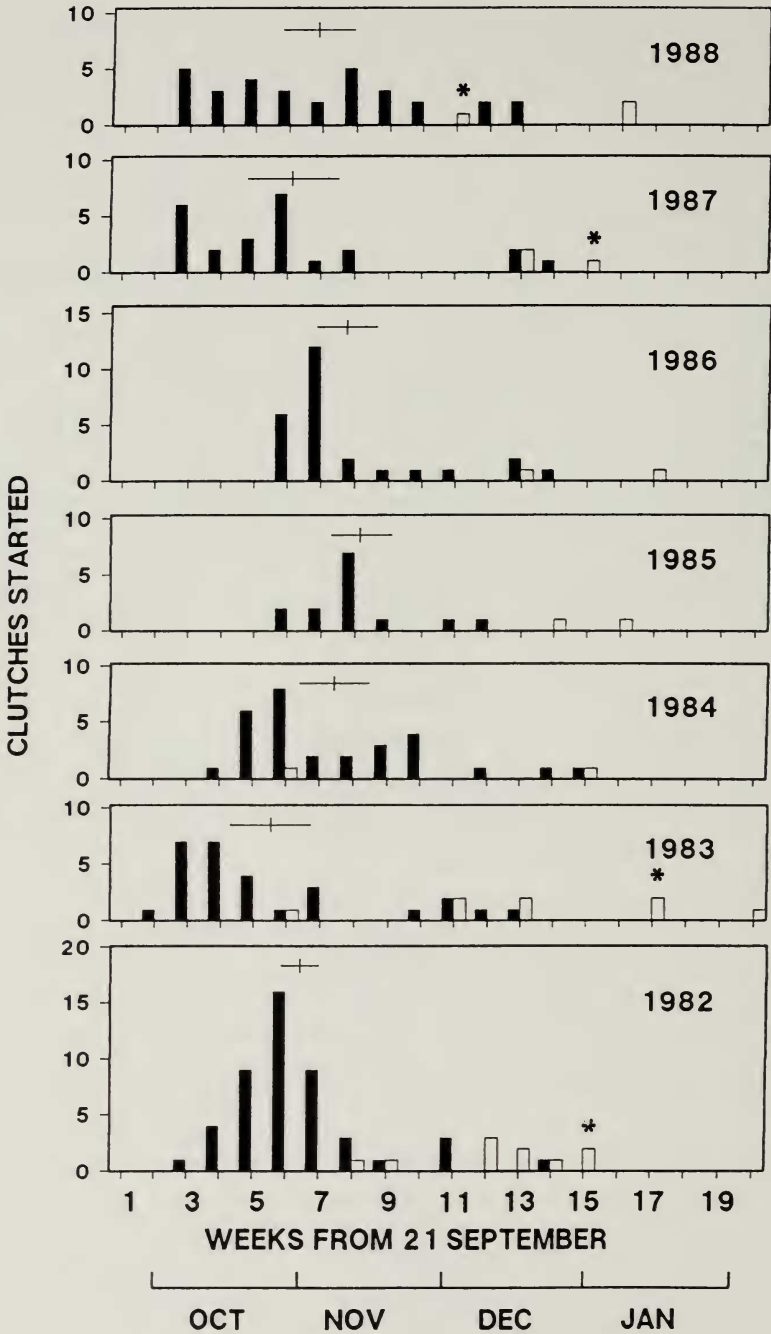
Given that periodic nest visitation has been reported as a factor that reduces nesting success in various avian species (Robert and Ralph 1975, Burt and Tuttle 1983, Westmoreland and Best 1985), we attempted to evaluate the effect of the observers' disturbance on reproductive success by comparing the fledging recruitment in the studied population in J. María with that of undisturbed nests located in a 200-m-wide strip surrounding the study area. The reproductive output of both populations was measured from 1986 to 1988 by comparing the juvenile/adult ratio of birds in samples caught during the post-breeding season (mid-February to mid-March) using the nest trapping method described by Martella *et al.* (1987). The age class of all newly captured (unbanded) individuals was determined by the presence of remige molting (Navarro and Bucher, unpubl. data). We assumed that, at the time the samples were taken (late summer), dispersion had not yet taken place and that the juvenile/adult ratio would provide an unbiased estimation of overall productivity.

RESULTS

Compound nest size.—At Arroyito, 62% of the nests had only one chamber, 33% two, 5% one, and none had four. At Jesús María, proportions (all years grouped) were 73%, 19%, 6%, and 2%, respectively. Differences in percentages between areas were not significant (Chi-square test; $\chi^2 = 3.85$, $df = 3$, $P = 0.278$).

Timing of laying.—At Arroyito, mean clutch initiation date was 1 November (range: 12 October–21 December). In J. María, the overall mean was 5 November (range: 2 October–28 December). Yearly means at this site varied within a 19-day range from 26 October in 1983 to 14 November in 1985 (Fig. 1). The earliest initial egg laying was recorded on 1 October 1983 and the latest on 29 October 1985. Laying synchrony was highest in 1985 and 1986 (Fig. 1). The time-span required at both areas for the initiation of 90% of first clutches was almost nine weeks (from October to December). Throughout the study, 28 replacement clutches and five second clutches were laid from mid-November to early January at Arroyito and from late October to early February at J. María (Fig. 1).

Breeding attempts.—The percent of occupied nest chambers found with at least one egg differed significantly ($\chi^2 = 26.92$, $df = 1$, $P < 0.001$) between Arroyito (91%) and J. María (53% overall) (Table 1). At Arroyito,



35% of the breeding pairs that were not successful in fledging at least one chick with their first clutch began replacement clutches. At J. María, an overall 20% of unsuccessful pairs started replacement clutches. Neither the differences in percentage of replacement among years in J. María ($\chi^2 = 3.03$, $df = 5$, $P = 0.696$) nor between the two areas ($\chi^2 = 1.77$, $df = 1$, $P = 0.183$) were significant. Second clutches were rare, two being recorded in 1982 and one each in 1983, 1987, and 1988. This means that <2% of total breeding pairs each year began second clutches, and for all years, only 5% (5 of 99 cases) of those pairs that were successful with their first brood began second clutches.

Clutch size.—Mean number of eggs in first clutches at Arroyito (6.0 ± 0.24 eggs [SE]) was significantly different from that at J. María (overall mean 5.4 ± 0.13) (Mann-Whitney test; $Z = 3.27$, $P = 0.001$). Clutch sizes ranged from one to 11 eggs at Arroyito and one to nine eggs at J. María; in both sites >73% of clutches had five to seven eggs. Yearly means in J. María ranged from 6.1 ± 0.41 eggs in 1985 to 5.1 ± 0.24 in 1987. Mean clutch sizes were higher and fluctuated more from 1983 to 1985 than in later years; after a decline in 1986, they were relatively constant. However, differences among years in J. María were not significant (Kruskal-Wallis test; $Z = 9.57$, $P = 0.088$).

Non-first clutches (replacement and second clutches) were significantly smaller than the respective first clutches (Wilcoxon paired rank test; $Z = 2.89$, $N = 33$, $P = 0.004$). The mean difference between the first and the non-first clutch was 1.1 ± 0.34 eggs. Replacement (4.9 ± 0.21 eggs) and second clutches (4.0 ± 0.84) were not significantly different in size (Mann-Whitney test; $Z = 1.22$, $P = 0.221$).

Hatching success.—In Arroyito, 216 out of 373 (58%) eggs hatched, while at J. María overall hatching success was 55% (Table 1); the difference between areas was not significant ($\chi^2 = 0.69$, $df = 1$, $P = 0.408$). Discrepancies between years in J. María were significant ($\chi^2 = 19.90$, $df = 5$, $P = 0.001$) due to the presence of two years of high success (1986 and 1988) and one year of extremely low hatching success (1983) (Table 1).

Hatching success of replacement and second clutches was significantly lower than that of first clutches in both areas (Table 1) (Arroyito: $\chi^2 = 22.22$, $df = 1$, $P < 0.001$; J. María: $\chi^2 = 8.45$, $df = 1$, $P = 0.004$).

FIG. 1. Frequency distribution for Monk Parakeet clutch initiations at Arroyito (1982) and J. María (1983–1988). Mean first clutch initiation date (vertical lines) and its 95% confidence interval (horizontal lines) are plotted above each histogram. Unshaded bars indicate re-layings. Each asterisk represents the occurrence of a second clutch.

TABLE 1
BREEDING STATISTICS OF MONK PARAKEETS

Parameter	J. María							
	1982	1983	1984	1985	1986	1987	1988	
Number of occupied nest chambers sampled	52	40	46	38	55	78	56	
Percent chambers with eggs (% breeding pairs)	91	70	63	37	49	42	68	
Number of eggs laid in first clutches	320	166	160	85	137	167	199	
Mean size of first clutches	6.0	5.9	5.5	6.1	5.1	5.1	5.2	
Hatching success (nestlings/eggs)	0.63	0.48	0.60	0.52	0.66	0.57	0.61	
Fledging success (fledglings/nestlings)	0.55	0.08	0.40	0.36	0.63	0.55	0.42	
Breeding success (fledglings/eggs)	0.35	0.04	0.24	0.19	0.42	0.32	0.26	
Percent successful first clutches ^a	51	14	38	50	48	52	53	
Percent of pairs re-laying ^b	21	29	10	14	11	9	8	
Mean size of replacement/second clutches	4.8	5.1	4.3	5.0	4.0	4.3	5.0	
Hatching success of replacement/second clutches	0.28	0.20	0.46	0.50	0.42	0.31	0.50	
Fledging success of replacement/second clutches	0.20	0.41	0.33	0	1.0	0	0.80	
Breeding success of replacement/second clutches	0.06	0.20	0.15	0	0.42	0	0.27	
Percent successful replacement/second clutches ^c	9	25	33	0	67	0	67	
Overall productivity per pair ^d	2.2	0.5	1.4	1.1	2.3	1.6	1.4	
Overall productivity per occupied chamber ^e	2.0	0.4	0.9	0.4	1.1	0.7	1.0	

^a Clutches producing at least one fledging/breeding pair.

^b Includes replacement and the following second clutches: 2 (1982), 1 (1983), 1 (1987), 1 (1988).

^c Clutches producing at least one fledging/breeding pair that re-laid.

^d Total fledglings produced/breeding pairs.

^e Total fledging produced/occupied chambers.

Differences in hatching success between replacement (26%) and second clutches (35%) were not significant ($\chi^2 = 1.22$, $df = 1$, $P = 0.270$).

Fledging and breeding success.—A significantly higher proportion (53% overall) of nestlings survived from hatching to fledging at Arroyito ($\chi^2 = 7.42$, $df = 1$, $P = 0.006$) than at J. María (Table 1). Overall fledging success at J. María ranged from 14% to 65%, with an average of 42%; differences among years were significant ($\chi^2 = 57.47$, $df = 5$; $P < 0.001$).

At Arroyito, fledging success of non-first clutches was significantly lower than first clutches ($\chi^2 = 5.61$, $df = 1$, $P = 0.018$); but no significant differences were found at J. María ($\chi^2 = 0.03$, $df = 1$, $P = 0.864$). Discrepancies between replacement (25%) and second clutches (35%) were not significant ($\chi^2 = 0.29$, $df = 1$, $P = 0.588$).

Significantly more eggs produced fledging young at Arroyito (27%) than at J. María (23% overall) ($\chi^2 = 7.76$, $df = 1$; $P = 0.005$).

Productivity.—Mean number of young fledged per breeding pair was 2.2 ± 0.32 at Arroyito. At J. María the overall mean was 1.4 ± 0.15 , with yearly means ranging from 0.5 ± 0.24 in 1983 to 2.3 ± 0.48 in 1986. Although there was no significant difference in productivity between areas, the test was close to the significance level of 0.05 (Mann-Whitney test; $Z = 1.87$, $N = 222$, $P = 0.061$).

Significant differences were found among years in J. María (Kruskal-Wallis test; $Z = 12.33$, $P = 0.031$). The 1983 breeding season was notable for the comparatively high mean first clutch size and for being the one with the lowest productivity.

Reproductive success (proportion of females that successfully fledged at least one young) did not differ significantly between areas ($\chi^2 = 0.59$, $df = 1$, $P = 0.443$). However, in J. María the low success of 1983 led to significant differences among years ($\chi^2 = 11.98$, $df = 5$, $P = 0.035$).

Causes of mortality.—The importance of different causes of loss varied significantly either among years at J. María ($\chi^2 = 180.66$, $d.f. = 20$, $P < 0.001$) or between study areas ($\chi^2 = 58.55$, $df = 5$, $P < 0.001$). Whereas percentage of losses due to predation, failure to hatch, and nest fall were slightly higher at Arroyito, deaths in the nest and partial losses were proportionally higher at J. María (Fig. 2). Overall, from 1982 to 1988, 23% of losses to the 1405 eggs laid was attributed to predation on eggs and chicks, 16% to partial disappearance; 16% to failure to hatch; 10% to deaths in the nest; 4% to nest fall; and less than 1% due to manipulation (only eggs were affected).

Circumstantial evidence for repeated predation by white-eared opossums (*Didelphis albiventris*) and grass snakes (*Philodryas patagoniensis*) was strong in both study areas (see also Martella and Bucher 1984, Martella et al. 1985). Both at Arroyito and J. María, two nests were attacked

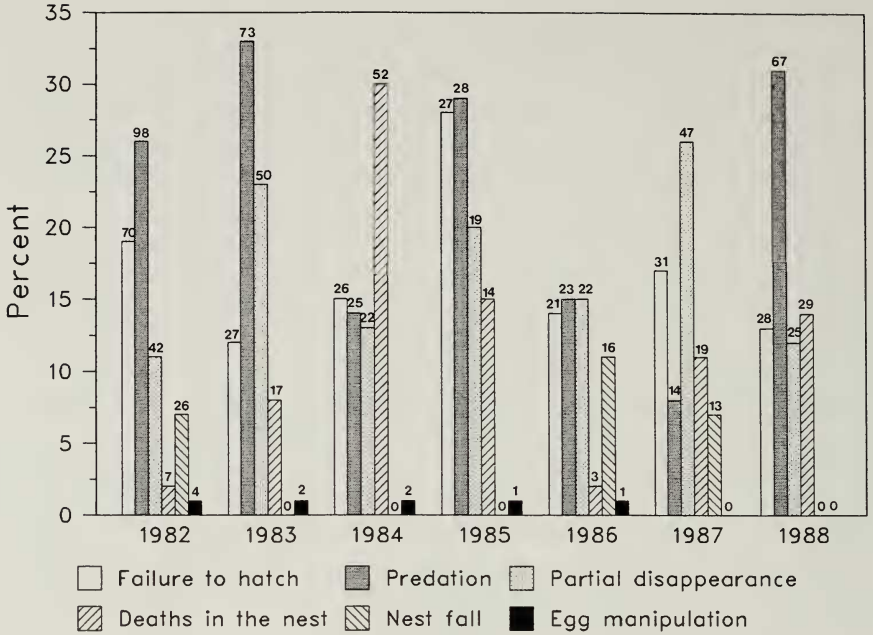


FIG. 2. Percentages of Monk Parakeet eggs and chicks lost with respect to the total number of eggs laid in that year. Values above bars are absolute frequencies.

and occupied by opossums. One night during early 1989, we observed an opossum that was trying to invade a Monk Parakeet nest. Also, in summer of 1983, we discovered a grass snake inside a nest as it was eating nestlings.

Effect of disturbance on reproductive outcome.—The overall juvenile/adult ratio determined in three post-breeding trapping opportunities at J. María (from 1986 to 1988) on the study area (0.40) did not differ significantly from the undisturbed area (0.37) ($\chi^2 = 0.03$, $df = 1$, $P = 0.865$), supporting the hypothesis that disturbance by observers did not affect breeding success.

DISCUSSION

Although the breeding season of the Monk Parakeet is restricted to spring and summer, and thus apparently controlled primarily by photoperiod, the average date of onset of breeding at J. María varied within a three-week period throughout the six monitored years (1983–1988). This slight shift in the dates of initiation of egg-laying may be related to other secondary environmental factors such as temperature, and food supply (Navarro and Bucher, unpubl. data). The Monk Parakeet has fewer year-

TABLE 2
COMPARISON OF BREEDING PARAMETERS AMONG THE MONK PARAKEET AND OTHER PSITTACIDS

Parameter	Monk Parakeet ^a	Australian parrots ^b	Cuban Parrot ^a
Clutch size	6	4 ^c	3
Percent hatching success	56	70 (50–82) ^d , 54 ^e	46
Percent fledging success	45	53 (43–72) ^d	67
Percent breeding success	25	40 ^e	31
Percent successful attempts	47	50 (35–66) ^f , 63 ^e	45
Juveniles fledged per breeding pair	1.5	1 (0.3–2) ^d	1
Nestling period (days)	35	37 ^e	

^a This study (unweighted mean, both areas combined).

^b Average (range given in parentheses).

^c Calculated for a body weight of 93 g using the equation of Saunders et al. (1984).

^d Smith and Saunders (1986).

^e Wyndham (1981).

^f Saunders and Ingram (1987).

^g Calculated from Gnam (1988).

to-year fluctuations than other psittacids from similar latitudes, such as Carnaby's Cockatoo (*Calyptorhynchus funereus latirostris*; Saunders and Ingram 1987) in Australia, which exhibits a five to seven-week range. On the other hand, our results show that Monk Parakeet populations are less synchronous in laying (nine weeks on average for the completion of first clutches) than those of most Australian parrots studied by Smith and Saunders (1986), the closest being the Red-tailed Black Cockatoo (*Calyptorhynchus magnificus*).

The clutch size of the Monk Parakeet is larger than that of most psittacids studied in detail (Table 2). This large clutch size counterbalances for the Monk Parakeet's lower fledging and breeding success (Table 2). A lower breeding success is consistent with the idea that the stick nest built by the Monk Parakeet, although safer than an open nest, is less secure than tree or cliff cavities. This issue may in turn have favored selection for a faster growth rate of nestlings (Navarro and Bucher 1990) and a shorter fledging period (Table 2).

An unexpected finding of our research is that a substantial and variable proportion of birds do not breed every year. Variations in the proportion of breeders modify the growth rate of Monk Parakeet populations through a change in the birth rate (Navarro and Bucher, unpubl. data). Therefore, an estimation of the fraction of breeders within the population should be used when developing demographic studies in parrots.

Although we found significant differences in some breeding parameters between Arroyito and J. María (particularly in percentage of chambers

with eggs and overall productivity per occupied chamber), comparison between the two areas must be made cautiously, given that we have data from only one breeding season and so lack information on annual variability in breeding statistics at Arroyito. Even if inconclusive, our findings suggest that the breeding performance of Monk Parakeets is better at Arroyito than at J. María. Possible hypotheses to explain this difference could be: (1) a higher quality or quantity of food sources at Arroyito; (2) eucalyptus trees are a better breeding habitat for this bird species than lower native vegetation; or (3) both factors combined.

Unfortunately, the lack of concurrent data on food supply at both study areas precludes us from testing the influence of this factor on productivity of Monk Parakeets.

Plantations of eucalyptus often enable higher densities of nests, which in turn could facilitate social interactions such as social stimulation, enhancement of foraging, and helping behavior, among others. Previous studies on the social organization of the Monk Parakeet revealed that such interactions appear to play a meaningful role in this higher gregarious bird species (Martella 1985; Bucher et al., in press.) and could yield a higher fitness. On the other hand, the predation rate was slightly higher at Arroyito, suggesting that neither nests in eucalyptus are safer than in lower vegetation nor that higher population densities would favor predator deterrence. However, human predation (e.g., pest control campaigns or harvesting of chicks for pet trade) should not be underrated as a cause of disturbance under normal circumstances. We do not evaluate here the importance of this factor, as it was restricted throughout our study. However, we think that Monk Parakeets often construct their nests as high as possible to reduce human disturbance.

Should we consider, therefore, eucalyptus as an optimal habitat for Monk Parakeets? Fretwell and Lucas (1969) defined optimal breeding habitats as those in which reproductive output is maximum, less-optimal habitats being selected only when density in optimal habitats is high enough to reduce fitness to a lower value than that observed in sub-optimal habitats. Accordingly, as the reproductive output was higher in eucalyptus trees, and assuming that habitat quality is somehow related to nest location, Monk Parakeets should construct the nest on eucalyptus trees wherever they are available. There is evidence confirming that this psittacid shows an apparent preference for nesting in eucalyptus or other tall trees or human structures (Bucher and Martin 1987) rather than lower native vegetation (Navarro, pers. obs.). This provides some support to Forshaw's (1978) argument that the introduction of eucalyptus trees has favored the distribution and abundance of the Monk Parakeet in the Pampas region.

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